Baseline Study for Husk Fired Captive Power Plant & Process Boilers

Final Report

Prepared for Indian Acrylics Limited, Chandigarh.

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1 Executive Summary

Background

Indian Acrylics Limited is the largest producer of Acrylic Staple Fiber in the country. Steel Strips Group promoted Indian Acrylics. Other business interests of the Steel Strips Group include, wheel rims, real estate and construction. The facilities for production of acrylic fiber were commissioned in the year 1993 at Sangrur district of Punjab State. The present capacity for production of acrylic fibers is 36000 tons per annum. The technology for the process plant was supplied by M/s E I Dupont Nemorous & Company USA.

For production of Acrylic Fibers process steam is used. The power requirement of the process plant is about 5.8 MW. As per the norms of the technology supplier the requirement of process steam and power for production of acrylic fiber were as follows:

- Process Steam   9.50 tons / ton of fiber
- Electricity   1975 Units / ton of fiber

Over a period of time Indian Acrylics has carried out modifications and alterations in the process plant with the objective of reducing energy intensity for production of fibers. The interventions include replacement of vapor compression refrigeration with vapor absorption refrigeration and incorporation of an additional stage in the solvent recovery cycle. Due to these and other interventions the present norms of consumption for process steam and electricity are as follows:

- Process Steam   4464 Thousand K Cal in steam / ton of fiber
~ 6.9 tons of steam / ton of fiber
- Electricity   1296 Units / ton of fiber

With the objective of meeting the energy requirements (both process heat and power) of the process plant in a more sustainable manner, Indian acrylics has converted its oil fired boilers to husk fired boilers and is putting up captive rice husk fired power plant.

As rice husk is a carbon neutral fuel. Indiàn Acrylics wish to register conversion of oil fired boilers to rice husk boilers and generation of power using rice husk under the Clean Development Mechanism (CDM) of the Kyoto

Protocol, and offer the Certified Emission Reduction Units (CERs) generated to the prospective buyers. The client had retained the services of TERI to carry out a baseline study for the purpose. The assignment has since been completed findings of which are given in this report. Summary of the findings is given in the following paragraphs.

Project Details

Indian Acrylics Limited has already implemented part of the GHG mitigation project and balance of the project is presently under implementation. Brief details of the project are given in the following paragraphs.

Fuel Switch from Oil to Rice Husk for Process Steam

Till recently the requirement of process steam was met by on site oil fired process steam boilers. Oil-fired boilers has been converted to rice husk fired fluidized bed boilers, in phases starting from the year 2000. The specifications of the oil-fired boilers being used earlier are as follows:

Specifications of Oil fired Boilers	
Boiler Number	One, Two and Three
Boiler Serial Nos. (as per IBR inspector)	PI 3607, PI 3608 and PI 3609
Make	IAEC India Limited, Mumbai
Number of boilers	Three
Type	Oil fired, smoke tube, three pass, wet back
Design Pressure	19 Kg / Sq. Cm (g)
Operating Pressure	17 Kg/ Sq. Cm (g)
Rated Out put	16000 Kg / Hr. (F&A 100 degree C)
Superheated steam	13310 Kg / Hr. at 225 +/- 10 Degree. C
Degree of Super Heat	20 degree
Steam to deaerator	1300 Kg / Hr.
Steam for oil preheating	240 Kg / Hr.
Fuel and its Calorific value	LSHS / HPS, 9600 K Cal / Kg (NCV)
Fuel Firing rate at rated capacity	1023 Kg /Hr
Type of Burner	Pressure jet spill return
Burner Turn Down Ratio	1:4
Thermal Efficiency on NCV	88 Percent

Specifications of Oil fired Boilers	
Boiler Number	Four
Boiler Serial Nos. (as per IBR inspector)	PI 3606
Make	Thermax, Pune
Number of boilers	One
Type	Oil fired smoke tube
Operating Pressure	17 Kg/ Sq Cm (g)
Rated Out put	16000 Kg / Hr. (F&A 100 degree C)
Superheated steam	at 225 +/- 10 Degree. C

Degree of Super Heat	20 degree C
Fuel and its Calorific value	LSHS / HPS, 9600 K Cal (NCV)
Burner Turn Down Ratio	1:4
Thermal Efficiency on NCV	88 Percent

After accounting for the boiler blow down, steam for oil preheating, steam for deaeration and considering condensate recovery of 60 percent at 80 degree C, the generation of process steam at actual working conditions has been determined. Under actual working conditions each of the boiler is capable of producing 13584 tons of steam per hour at 18 Kg./ sq. Cm pressure and 225 degree C at the rated capacity.

A part of the process steam is required at 425 deg. C., which was earlier produced by passing the saturated steam through a separate oil fired steam super heater.

While converting the oil fired boilers to husk fired boilers the steam pressure and degree to super heat of the output steam has been increased to increase the overall efficiency. There are plans to put one turbine of 1 MW capacity on boilers for process steam which has already been converted to husk fired boiler. The process steam boilers will then be operated in co-generation mode. The power will be sold to the other sister concerns located elsewhere. For the purpose transmission and distribution net work of Punjab State Electricity Board will be used. The specifications of the boilers after conversion to husk firing are as follows:

Specifications of Process Steam Boiler after Conversion to Husk Firing	
No. of boilers	3 (2 working and 1 stand by)
Boiler Serial Nos.	PI 3607, PI 3608 and PI 3609
Type of boiler	Atmospheric Fluidized Bed
Capacity of Each Boiler	16 TPH at 18.75 Kg/Sq. cm & 350 Degree. C, or 11 TPH at 18.75 Kg/Sq. cm & 350 Degree C And 5 TPH at 18.75 Kg/Sq. cm & 425 Degree C.
Steam Parameters	18.75 Kg. / Sq. cm. 350 Degree C.
Fuel	Rice Husk
Feed Water Temp.	140 Degree C (After economizer)
Calorific Value of Fuel	3300 -3500 kcal / kg.
Thermal Efficiency (on GCV)	83 +/- 2 %

Process steam boilers now uses rice husk as fuel. It is proposed that the process steam boilers be operated in co-generation mode after putting a back pressure type steam turbine of 1 MW capacity. This part of the project will mitigate

emission of carbon- dioxide firstly due to replacement of fossil fuel with a carbon neutral fuel and secondly due to generation of power using a carbon neutral source of energy. The project boundaries for mitigation of GHG due to process steam will be the physical boundaries of the process plant. The mitigation of GHG due to production of power (due to operation in Co-generation mode) will take place at the fossil fuel based power plants at different locations, which supply power in the state of Punjab.

The total cost of the project is about Rs.80 Million. The project is funded completely from internal cash accruals. The project apart from mitigating the emission of GHG reduces the local emissions of sulfur and other pollutants like particulate matter, heavy metals and nitrous oxide, associated with the burning of fossil fuels. The project is in line with the development priorities of the local government of increasing the use of renewable sources of energy. The project has led to generation of employment at the local levels for collection and supply of rice husk. The project has led to increase in the income of the local farmers, as they are now able to get money for the agro-residue for which there was hardly any market. Most of the husk earlier in the absence of any market use to get rotten in the fields leading to emission of methane.

Rice Husk Fired Captive Power Plant

The power requirement for operating the process plant is about 5.8 MW. Presently the power requirement is met by, supplies from Punjab State Electricity Board. Indian Acrylics is converting / putting up more rice-husk based boilers along with turbo generators of aggregate capacity of 6.5 MW to meet its power requirements from captive sources. After satisfying the captive needs of power the project will supply the balance power to other companies in the group using the grid of PSEB. The specifications of the boilers and the turbo generators are as follows:

Specifications of Power Boilers	
No. Of boilers	2
Type of boiler	Atmospheric Pressure Fluidized Bed (FBC)
Capacity of Boiler	21 TPH (From and at 20 Kg. / sq. cm & 350 Degree C)
Steam Parameters	19 Kg. / Sq. cm (g), 350 Degree C.
Fuel	Rice Husk or 70 Percent Husk 30 % Straw / Bagasse
Calorific Value of Fuel	3300 k Cal / kg.
Thermal Efficiency (on GCV)	83+/-2 %
Furnace type	FBC (over bed firing)
Depth of Bed Material	220-250 mm
Connected Load	183 kW

Specifications of Turbo Generators	
Power at alternator terminals	6.5 MW
Type	Multistage, impulse, horizontal, condensing type
Inlet steam pressure	18.75 Kg./Sq. cm (g)
Inlet Steam temp.	350 Degree C.
Exhaust pressure	0.1 Ata
Inlet steam flow	40 TPH
Bleed to deaerator	4 TPH
Steam to Condenser	36 TPH
Generator Rating	8125 KVA
Power Factor	0.8
Generation	6500 kW
Generation Voltage	6600 Volts
Frequency	50 Hz.

The operation of the captive rice husk based power plant will lead to mitigation of emission of carbon di-oxide, as husk is a carbon neutral fuel. The captive power project will be put up in the existing physical boundaries of the process plant. The mitigation of GHG emissions will take place in the fossil fuel based power plant, which supply power to the sate of Punjab.

Capital cost of this part of the project has been Rs.144.5 Millions. The project is being funded completely from internal cash accruals. The project apart from mitigating the emission of GHG will reduce the local emissions of sulfur and other pollutants associated with the burning of fossil fuels. The project is in line with the development priorities of the local government of increasing the use of renewable sources of energy and development of power sector. The project will lead to generation of employment at the local levels for collection and supply of rice husk. The project will lead to increase in the income of the local farmers, as they will be able to get money for the agro-residue for which there was hardly any market.

Base Line of the Projects

The potential CDM project mitigates emission of green house gases in following three ways.

- Avoidance of use of fuel oil for production of process steam.
- Avoidance of use of fossil fuels, for generation of power by state utilities for supply to the sister concern.
- Avoidance of use of fossil fuel for generation of power by state utilities for supply of power.

The extent of mitigation of emission of GHG in the three cases is different. Thus three different base lines have been considered for the three components of the project. In case of steam produced in the process boilers, steam generation in the oil fired process boilers has been considered as the baseline. For power supplied to other companies, the power fed to the grid by the power producing units in the state has been considered as the base line. In case of captive power consumption the base line considered is power supply from Punjab State Electricity Board to the consumers in Punjab. As it is not possible to estimate the extent of emission of GHG other then carbon di-oxide only carbon di-oxide has been considered.

Emissions in the Base Line Scenario

Captive Power Consumption

Rice husk fired captive power plant is being put up within the existing boundaries of the process plant. As has been stipulated before the mitigation of GHG due to operation of captive power plant will take place at the fossil fuel based power plants, which supply power to the state of Punjab. To estimate emission of carbon dioxide in the baseline scenario, the factors considered are as follows:

- Current fuel-mix of power generation and supply in the state of Punjab.
- Station heat rate of the power plants supplying power to Punjab.
- Technical losses in the transmission and distribution of power in the state of Punjab.

The power generation mix for the state of Punjab in the year 1999-2000 was as follows:

Table: 1.1 Source Wise & Fuel Wise Break Up Power Supply - Punjab, 1999-2000

	Capacity (MW)		Supply (Million Units)	
	Allocated / Effective Capacity	Percent Distribution	Supply at the bus bar	Percent Distribution
State				
Hydro	1155	19.96	3230.2	12.39
Gas	0	0.00	0	0.00
Nuclear	0	0.00	0	0.00
Coal Based Thermal	2130	36.81	12641	48.48
Centre				
Hydro	1734	29.96	6153	23.60
Gas	244	4.22	1412	5 42
Nuclear	118	2.04	186	0.71
Coal Based Thermal	406	7.02	2450	9.40

Total				
Hydro	2889	49.92	9383.2	35.99
Gas	244	4.22	1412	5.42
Nuclear	118	2.04	186	0.71
Coal Based Thermal	2536	43.82	15091	57.88

For estimating emission intensity of fossil fuel based power plants characteristics of different fuels used has been considered to be as given in **Table 1.2** below.

Table: 1.2 Characteristics of Fossil Fuels used in Power Plants

Naphtha	
Carbon content by Wt.	80 Percent
Calorific value	10750 K Cal / Kg.
Percent Oxidisation	99 Percent
Natural Gas	
Carbon Content by Wt.	75 Percent
Calorific Value	12300 K Cal / Kg.
Percent Oxidisation	99.5 Percent
Coal	
Carbon Content	40 Percent
Calorific Value	3600 K Cal / Kg.
Percent Oxidisation	98 Percent

Considering the heat rates of different fossil fuel based power plants in Punjab and the contribution by different fossil fuel based power plants towards the supply of power to the state of Punjab in the year 1999-2000 the emission of carbon di-oxide in the year has been estimated. The total emission of GHG for supplying power to the distribution grid of PSEB in the year 1999-2000 was 19524 million Kg of carbon di-oxide. Total power supplied to the grid in the same period was 26072 million units, out of which 16503 million units were supplied by the fossil fuel based power plants and the balance was supplied by the power plants based on other sources of energy. Thus the emission of GHG for supplying one unit of fossil fuel based power to the grid has been estimated to be 1.1831 Kg of carbon di-oxide. The emission of GHG for supplying one unit of power at an aggregate level has been 0.7489 Kg of carbon di-oxide.

The transmission and distribution losses in the state of Punjab for the year 1999-2000 were 17.25 percent. The power to large industries like Indian Acrylics is supplied in high traction form. Most of the losses in the transmission and distribution of power takes place for transmission and distribution in low traction form. Thus the transmission and distribution losses in the HT form has been considered at 5 percent. Based on the above the emission of CO_2 for every unit of fossil fuel based power supplied to Indian Acrylics in the year 1999-2000

has been worked out to be 1.2454 Kg. The emission of GHG for supplying power to Indian Acrylics at an aggregate level has been estimated to be 0.7883 Kg., of carbon di-oxide per unit of power.

Thus the emission of GHG in the base line scenario for generation and supply of power to consumers in Punjab for the year 1999-2000 has been estimated to be as given in Table 1.3 below:

Table 1.3: Power Supply and Emission of GHG in Punjab: 1999-2000

Total power supply to PSEB grid	26072	Million Units
Fossil fuel based power supply to PSEB grid	16503	Million Units
Transmission & distribution loss	5.00	Percent
Emission of CO2 for power supply to grid of PSEB	19524	Million Kg.
CO2 emission for power supply to grid	0.7489	Kg. / kWh
CO2 emission for fossil fuel based power supply to grid	1.1831	Kg. / kWh
CO2 emission for power supply to consumers	0.7883	Kg. / kWh
CO2 emission for fossil fuel based power supply to consumers	1.2454	Kg. / kWh

Generation of Process Steam

As mentioned before in case of steam produced in the process boilers, steam generation in the oil fired process boilers has been considered as the baseline. The emission of GHG in the base line scenario is the emission due to burning of oil for producing process steam in the base line scenario. Mitigation of GHG under the project is taking place due to fuel switching from fuel oil to rice husk for Process Steam Boilers. To estimate emission of carbon dioxide in the baseline scenario, the factors considered are as follows:

- Specifications of the oil fired boilers used earlier
- Thermal efficiency of oil fired boilers

The capacity of each of the oil fired process steam boiler was 16 tons per hour (from and at 100 degree C). A heat and material balance for the oil-fired boilers in actual working conditions has been carried out to determine the consumption of fuel and production of steam at actual working conditions. For details of the heat and material balance please refer the diagram provided below.

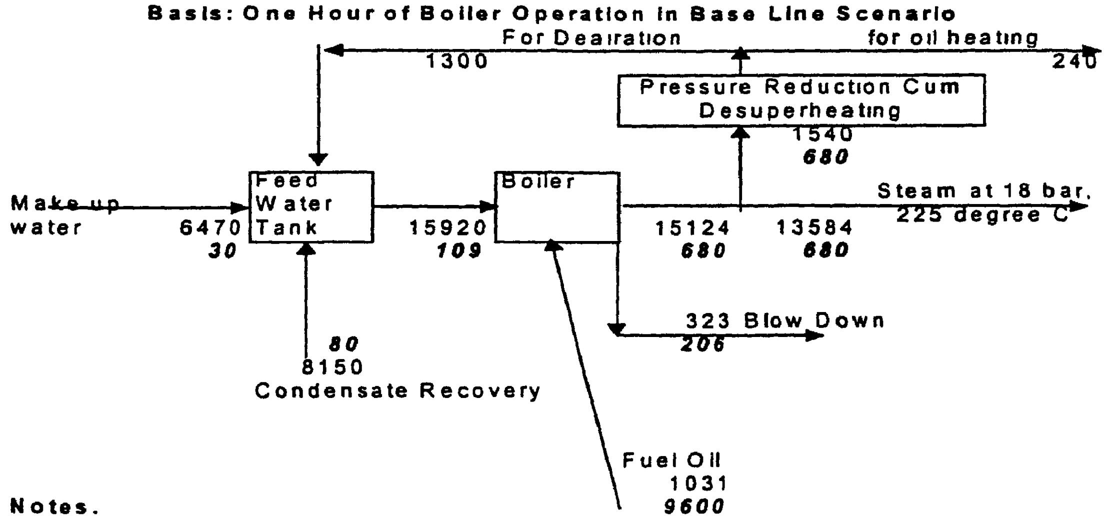
Based of heat balance and material balance of the steam generation system used in the base line scenario, it has been worked out that for every ton of process steam out of the steam generation system the consumption of fuel oil will be 75.9 kg. Apart from this some quantity of fuel oil is also used for converting part of the process steam to super heated steam at 425 degree C. The thermal efficiency of the oil fired steam super heater is much less then that of the process boilers. Considering thermal efficiency of 75 percent the

requirement of fuel oil for superheating one ton of process steam from 225 deg. C to 425 degree C has been estimated to be 15 Kg.

The emission of carbon di-oxide due to combustion of fuel oil have been worked out considering 80 percent carbon content in the oil by weight and 99 percent oxidization level of carbon in the oil. The emission of carbon di-oxide due to fuel oil for every ton of process steam produced at 18 Kg. / Sq. Cm and 225 degree C has been estimated to be 220.43 Kg of carbon di-oxide. The emission of carbon di-oxide for generation of steam at 18 Kg / Sq. Cm and 425 degree C is estimated to be 263.99 Kg of carbon di-oxide.

HEAT AND MATERIAL BALANCE

Basis: One Hour of Boiler Operation in Base Line Scenario



Notes.

Figures give mass flow rate in Kg / Hr

Figures indicated as *xxxx* give the heat content in K Cal per Kg.

Assumptions:

Condensate recovery = 60 Percent at 80 degree C

Boiler Blow Down = 5 Percent of feed water make-up

Thermal Efficiency of boiler = 88 Percent

Apart from combustion of fuel oil the emission of GHG in the base line scenario also takes place due to consumption of power for operation of the process steam generation facilities. The power is consumed for the operation of feed water pump, oil pump, condensate recovery pump and the ID fan. This factor has not been considered, as power will be required even after implementation of the project.

Quantum of CERs

Mitigation of GHG due to the project has been estimated to be as follows:

For power supplied to other concerns	1.1831 kg of carbon di-oxide per unit of power supplied to grid	
For power used with in the process plant.	1.2454 kg of carbon di-oxide per unit of net power produced in the captive power plant	
For process steam produced in the process boilers after switching the fuel from fuel oil to rice husk	220.43 kg of carbon di-oxide per ton of steam produced at 18 bar pressure and 225 degree C	
	264 Kg of carbon di-oxide per ton of steam produced at 18 bar pressure and 425 degree C	

Present norms of consumption of utilities in the process plant are as follows:

Process Steam	4464 Thousand K Cal per ton of acrylic fibers
Power	1296 units per ton of acrylic fibers

Superheated steam at 425 degree C and the steam at 225 degree C are used in the ration of 5:22. Thus it has been estimated that the process steam at 425 degree C and 225 degree C, required for production of one ton of fiber will be 1.3 tons and 6.9 tons respectively.

The capacity of the process plant is 36000 tons per annum of fibers. Considering total power generation capacity of 7.5 MW. The actual generation of power net of auxiliary consumption (considering PLF of 90 percent and auxiliary consumption of 10 percent) will be about 53.2 million units per annum. About 47 million units will be used in house in the process plant and the balance will be supplied to other concerns. Thus GHG mitigation potential of the project is estimated to be as follows:

Due to power supplied to other concerns	6200 kWh*1.1831 =	7335 tons of CO2 per annum
Due to captive power consumption	47000 kWh*1.245 =	58515 tons of CO2 per annum
Due to generation of process steam at 225 degree C	6.9*36000*220.43/1000 =	54755 tons of CO2 per annum
Due to generation of process steam at 425 degree C	1.3*36000*264/1000 =	12355 tons of CO2 per annum
Total		132960 tons of CO2 per annum

Possibilities for Monitoring and Verification

Based on the emission factors under the base line scenario and the capacity of the plant it has been estimated that the number of CERs that can be generated at 100 percent capacity utilization will be about 133 thousand numbers per annum. The actual number of CERs that will be generated in actual practice will be much less and will depend upon the capacity utilization of the process plant and working of the project. The use of fuel oil to support working of the husk fired process boilers and husk-based power plant is also required to be taken care of.

The potential CDM project is being implemented at the existing site of Indian Acrylics Limited. As three different base lines has been established for the potential CDM project, monitoring and verification of the CERs out of the project will be required to be done separately for the three cases.

Captive Power Consumption

Generation of power for captive consumption using rice husk, as fuel will lead to mitigation of GHG in the fossil fuel based power plants, which supply power to Punjab State. Mitigation of GHG due to generation of power in husk fired power plant is spread over large geographical area. However, it is possible to monitor the mitigation within the physical boundaries of the process plant. This is so as a fixed base line throughout the crediting period is being used.

In order to monitor mitigation of GHG due to generation of power in husk fired power plant it is required that the net power produced and supplied to the distribution system of the process plant be measured. It is proposed that a two-way meter be installed to measure the power fed to the distribution system of the process plant. A separate meter will measure the auxiliary power used for operation of the process plant. The difference of the readings in the two meters will provide the quantum of net power supplied to the distribution system of the process plant. Net power supplied to the process plant multiplied by the mitigation of GHG for every unit of net power supplied will provide the extent of mitigation of GHG over a period of time. Out of this the emission of carbon di-oxide due to use of auxiliary oil is required to be subtracted.

Power Supply to Other Units

For power generated in co-generation mode, the power fed to the grid by the power producing units in the state has been considered as the base line. The emission of GHG in the base line scenario will be the emission due to the operation of the power generating plants, which supply power to the state of Punjab. The monitoring and verifications of the mitigation of GHG can be done

in the premises of the power plant as a fixed base line is being used. The emission of carbon di-oxide in the base line scenario for supplying HT power to the consumers in the state has been estimated to be 1.8131 kg for every unit of power. This norm is proposed to be used through out the crediting period of the potential CDM project.

The monitoring and verification of CERs due to operation of process boilers in co-generation mode will be done based on the quantum of power fed to the distribution grid of PSEB. The power fed to the distribution grid of PSEB for onward transmission to the sister concern may be measured using an energy meter.

Process Steam

In case of process steam, steam generation in the oil fired process boilers has been considered as the baseline. The emission of GHG in the base line scenario is the emission due to burning of oil for producing process steam in the base line scenario. The extent of actual mitigation of GHG may be determined by determining the quantum of process steam generated. The monitoring of GHG mitigation in case of production of process steam may be done by measuring the quantum of process steam by using the steam flow meters at the out let of each boiler.

As the steam produced in the process boilers will be used in co-generation mode, there may be conditions when a part of the steam generated in the process boilers after expansion in the turbine will be condensed. Further there are three process boilers out of which two will be working at a time and one will be stand by. Depending upon the need the stand by process boiler may be used to feed the steam to the turbine of the power plant. Thus it is necessary that the generation and use of steam for heating applications be checked with the norms of consumption of process steam. GHG mitigation benefits due to switching the fuel from fuel oil to rice husk should be given on the least of the quantum of process steam determined by the two methods. Based on actual production of acrylic fibers and consumption of fuels and power over last two years the norms of consumption have been worked out. The norms of consumption of power and process heat in the past and at present are given in **Table 1.4**.

Table 1.4: Norms of Consumption of Utilities for Producing Acrylic Fibers

(Consumption Per MT of Fiber)

Time Frame	Power (kWh)			Heat (Ths. Kcal)		
	Avg.	High	Low	Avg.	High	Low
Present Status	1296	106%	91%	4464	104%	94%
Before Commissioning of Extra Effect in Solvent recovery & Vapor Absorption Chillers	1413	104%	88%	4558	104%	90%
After Commissioning of Extra Effect in Solvent Recovery & before Vapor Absorption Chiller	1437	105%	92%	3758	111%	76%
After Comm. Of Extra Effect in Solvent Recovery and Vapor Absorption Chillers	1280	107%	90%	4739	103%	95%

Notes:

1. Only that data set has been considered where the capacity utilization was 80 Percent or more. The consumption will increase in case of lower capacity utilization.
2. High and low indicates percentage of the average values.
3. For details of the workings please see Annexure - 5.1

Based on actual production of acrylic fibers the emission of GHG in the base line scenario can be determined by using the norms of consumption for utilities as provided above.

2 Background and Project Promoters

Background

Indian Acrylics Limited is the largest producer of Acrylic Staple Fibers in the country. It has its production facilities at Sangrur district in the state of Punjab. The present capacity for production of acrylic fibers is 36000 tones per annum. Indian Acrylics Limited was promoted by Steel Strips Group. Its facilities for production of acrylic fiber were commissioned in the year 1993 with an initial capacity of 12000 TPA. M/s E I Dupont Nemorous & Company USA supplied the technology for the process plant.

For production of Acrylic Fibers process steam is used. Till recently the requirement of process steam was met by oil fired process boilers. Oil-fired boilers has been converted to rice husk fired fluidized bed boilers, in phases starting from the year 2000. Further to this a turbine of 1 MW capacity on boilers for process steam which has already been converted to husk fired boiler is being put up. The process steam boilers will then be operated in co-generation mode. Surplus power will be sold to other sister concerns of the group located elsewhere. For the purpose transmission and distribution net work of Punjab State Electricity Board (PSEB) will be used. PSEB owns the power transmission and distribution grid in the state and has the mandate for distribution and supply of power in the state of.Punjab.

The power requirement of the process plant is about 5.8 MW. Presently the power requirement is met by, supplies from PSEB. Indian Acrylics is putting up more rice-husk based boilers along with the turbo generators of aggregate capacity of 6.5 MW to meet its power requirements from captive sources.

As rice husk is a carbon neutral fuel. Indian Acrylics wish to register conversion of oil fired boilers to rice husk boilers and generation of power using rice husk under the Clean Development Mechanism (CDM) of the Kyoto Protocol. Indian Acrylics will then offer the Certified Emission Reduction Units (CERs) generated to the prospective buyers. Indian Acrylics Limited had retained the services of TERI to carry out a baseline study for the purpose. The objectives of the assignment were as follows:

1. Establish the baseline for the CDM projects
2. Determine the baseline emissions of Green House Gases (GHG) for the Project
3. Determine the reduction in the emission of carbon dioxide due to the Project
4. Suggest a method for monitoring and verification of the reduction in carbon dioxide emissions due to the Project.

The assignment has since been completed, findings of which are given in this report. Summery of the findings of the study is given in Chapter One of the report. Following paragraphs give the details of the promoters, and the methodology used. Rest of the report is arranged as follows:

Chapter – 3	Project Description and Project Base Lines
Chapter – 4	Emissions in the Base Line Scenario
Chapter – 5	Possibilities for Monitoring and Verification

roject Promoters

The potential CDM project has been put up by Indian Acrylics Limited, at its existing works at Sangrur district of Punjab. Indian Acrylics Limited is a Public Limited Company with its registered office and works at Village Harkisanpur, District Sangrur, Punjab. Corporate office of the company is located at Chandigarh. The shares of the company are listed at Ludiana, Mumbai, Calcutta and Ahmedabad Stock exchanges. Financial institutions hold more then 25 percent of the subscribed share capital of the company. Present managing director Mr. R K Garg is one of the promoter directors of the company.

The potential CDM project is being financed completely from the internal cash accruals due to the present operations of Indian Acrylics Limited. Thus both the potential CDM projects are owned completely by Indian Acrylics Limited.

Aethodology

The baseline for the Project has been determined in accordance with the provisions in the Kyoto Protocol and Marrakesh accords as clarified from time to time. The base line in case of process steam generation has been considered as the oil fired process boilers. In case of captive power plant the base line considered is the power supply from Punjab State Electricity Board. To estimate emission of carbon dioxide in the baseline scenario in case of rice husk based captive power plant, the factors considered are as follows:

- Current fuel mix of power generation and supply in the state of Punjab.
- Station heat rate of the power plants supplying power to Punjab.
- Technical losses in the transmission and distribution of power in the state of Punjab.

To estimate emission of carbon dioxide in the baseline scenario in case of rice husk based process steam boilers, the factors considered are as follows:

- Thermal efficiency of oil fired boilers being used earlier
- Best achievable thermal efficiency of oil fired boilers under the current technology.

To determine the quantum of power likely to be produced, factors like, expected plant load factor, past performance of the boilers etc., has been taken into account. To determine the quantum of process steam likely to be produced the relationship between the production of acrylic fiber and requirement of process steam per unit of production has been considered. For identifying the possibilities regarding monitoring and verification of emission reduction, the configuration and arrangements of the Project along with the project boundaries has been considered.

3 Project Description and Project Base Lines

Background

Indian Acrylics Limited established its acrylic fiber production facility in the year 1993 with a capacity of 12000 Tones Per Annum (TPA). The present capacity of the plant is 36000 TPA of acrylic fibers. The technology for the process plant was supplied by E I Dupont Nemorous & Company USA. The production of acrylic fibers for last two years has been as follows:

2000-01	25683 Tons of acrylic fibers
1999-2000	32709 Tons of acrylic fibers

Apart from the raw materials for conversion to fibers the two other major inputs required for the process plant are steam and electric power. Process steam is used for heating applications in the process. The power requirement of the process plant is about 5.8 MW. As per the norms of the technology supplier the requirement of process steam and power for production of acrylic fiber were as follows:

Process Steam	9.50 tons / ton of fiber
Electricity	1975 Units / ton of fiber

Over a period of time Indian Acrylics has carried out modifications and alterations in the process plant with the objective of reducing the energy intensity for production of acrylic fibers. The interventions include replacement of vapor compression refrigeration with vapor absorption refrigeration and incorporation of an additional stage in the solvent recovery cycle. Due to these and other interventions at present the norms of consumption for process steam and electricity are much lower.

The present steam requirements in different sections of the process plant at rated capacity are given in **Table 3.1** below.

Table 3.1: Steam Requirements of Different Sections of Process Plant

(Figures in Tons)

User Sections	Pressure Kg/ Sq. cm (g)	Temp. Deg. C	Hourly Req.	Daily Req.	Annual Req.
Aspiration Gas Heaters	15	425	5	120	43800
Solvent Column, Tar still secondary gas heater	15	225	5.3	128	46720
Week feed vaporizer, polymer dryers, fiber dryers, waste dryers, wash draw, solution heaters, cell solution heaters, jacket / hot water heater/ vapor adsorption chillers	5.5	175	18.5	444	162060
Monomer recovery, solvent heaters to macro, reagent preparation, finish system	2.2	155	3	72	26280
Total			31.8	764	278860

The requirement of power by different sections of the process plant is as given in **Table 3.2** below.

Table: 3.2 Power requirement of Different Sections of Process Plant

(Figures in kW)

Section	Connected Load	Operating Load
Polymerization	2061	1308
Spinning	3053	1393
Fiber Line	1294	768
Utilities	3098	1200
Miscellaneous	741	330
Total	10247	4999

With the objective of meeting the energy requirements (both process heat and power) of the process plant in a more sustainable manner, Indian acrylics has converted its oil fired process steam boilers to husk fired boilers and plans to put up captive rice husk fired power plant.

As rice husk is a carbon neutral fuel. Indian Acrylics wish to consider conversion of oil fired boilers to rice husk boilers and generation of power using rice husk under the Clean Development Mechanism (CDM) of the Kyoto Protocol. Following paragraphs provide more details of the potential CDM project.

Project Description

As has been stipulated before Indian Acrylics Limited has already implemented one part of the potential CDM project and the second part of the project is presently under implementation Details of the project are given in the following paragraphs.

Fuel Switch from Oil to Rice Husk for Process Steam

Till recently the requirement of process steam was met by on-site oil fired process steam boilers. Oil-fired boilers has been converted to rice husk fired fluidized bed boilers. Detailed specifications of the oil-fired boilers being used earlier are given in **Annexure 3.1.** Basic specifications of the oil-fired boilers are given below.

Specifications of Oil fired Boilers	
Boiler Numbers	One, Two and Three
Boiler Serial Nos. (as per IBR inspector)	PI 3607, PI 3608 and PI 3609
Make	IAEC India Limited, Mumbai
Number of boilers	Three
Type	Oil fired, smoke tube, three pass, wet back
Design Pressure	19 Kg / Sq. Cm (g)
Operating Pressure	17 Kg/ Sq. Cm (g)
Rated Out put	16000 Kg / Hr. (F&A 100 degree C)
Superheated steam	13310 Kg / Hr. at 225 +/- 10 Degree. C
Degree of Super Heat	20 degree
Steam to deaerator	1300 Kg / Hr.
Steam for oil preheating	240 Kg / Hr.
Fuel and its Calorific value	LSHS / HPS, 9600 K Cal / Kg. (NCV)
Fuel Firing rate at rated capacity	1023 Kg /Hr
Type of Burner	Pressure jet spill return
Burner Turn Down Ratio	1:4
Thermal Efficiency on NCV	88 Percent

Specifications of Oil fired Boilers	
Boiler Numbers	Four
Boiler Serial Nos. (as per IBR inspector)	PI 3606
Make	Thermax, Pune
Number of boilers	One
Type	Oil fired, smoke tube
Operating Pressure	17 Kg/ Sq. Cm (g)
Rated Out put	16000 Kg / Hr. (F&A 100 degree C)
Superheated steam	at 225 +/- 10 Degree. C
Degree of Super Heat	20 degree C
Fuel and its Calorific value	LSHS / HPS, 9600 K Cal (NCV)
Burner Turn Down Ratio	1:4
Thermal Efficiency on NCV	88 Percent

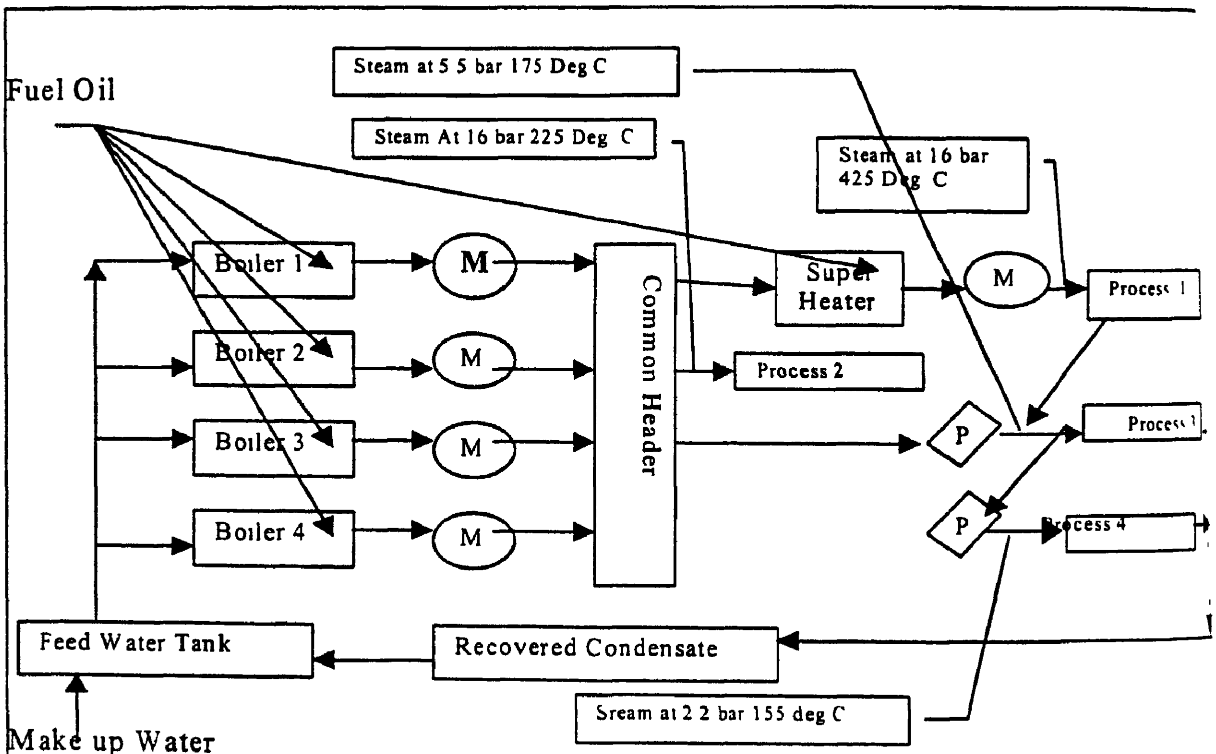
After accounting for

- boiler blow down,
- steam for oil preheating
- Steam for deaeration and

considering condensate recovery of 60 percent at 80 degree C,

each of the boilers is capable of producing 13584 tons of steam per hour at 18 Kg./ Sq. Cm (absolute) pressure and 225 degree C at the rated capacity.

For the super heated steam the steam generated in the boilers was earlier passed through separate external oil fired super heater. For the steam at lower pressure the high-pressure steam use to be passed through a pressure reducing cum de-superheating station. The overall system of operation has been depicted schematically in the diagram below.



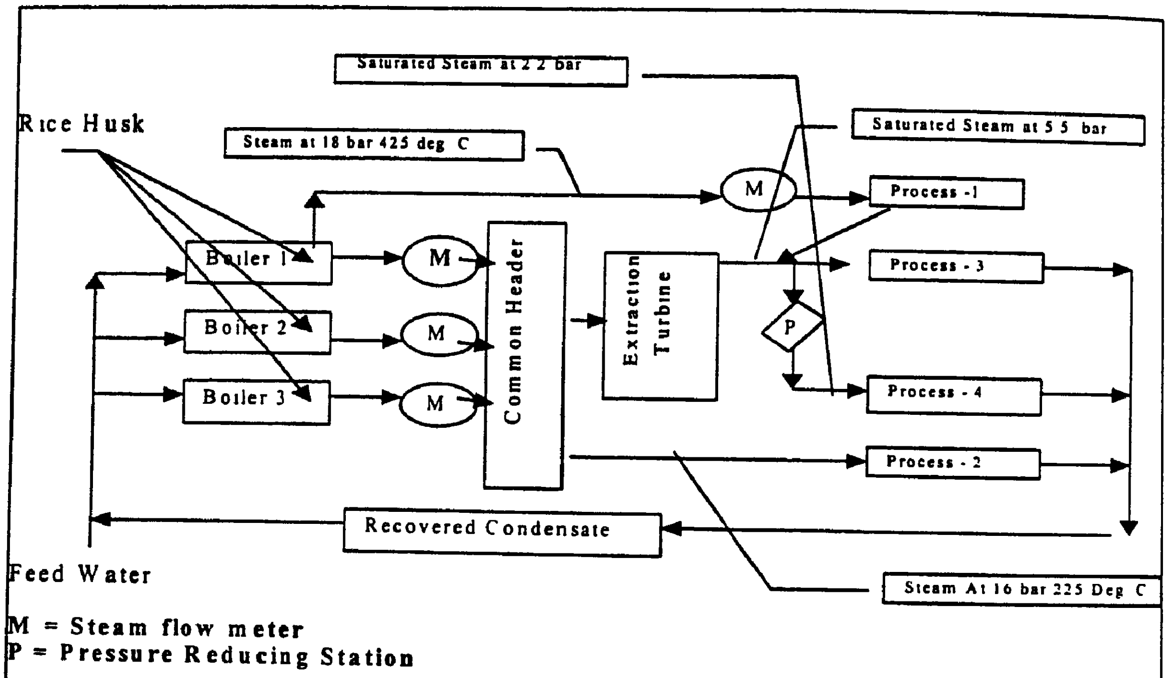
M = Steam Flow Meter
P = Pressure Reducing cum De-superheating Station

Operating System With Oil Fired Boilers

The oil-fired boilers have been converted to rice husk fired boilers. Three out of the four oil-fired boilers has been converted to husk firing. The capacity and the steam operating parameters of the boilers have also been increased. Out of the three boilers converted to husk firing provision has been made in two boilers for super heating the required quantity of steam to 425 degree C. Out of the three husk fired boilers two will be operating at a time and the third boiler will be stand by. At a time only one process boiler is required to generate the super heated steam.

It is now proposed that the pressure reducing cum de-superheating stations in the present system be replaced with a back pressure type steam turbine of 1 MW capacity. This will increase the overall efficiency of the system further. After commissioning of the steam turbine the power and process steam will be generated in co-generation mode. The power produced will be supplied to the sister concern of Indian Acrylics on commercial basis.

The system for generation and utilization of process steam after implementation of the potential CDM project of conversion of oil fired boilers to rice husk fired boilers is as given in the diagram below.



Operating System with Husk Fired Boilers

The oil fired boilers have been converted to rice husk fired fluidized bed boilers as per following schedule.

Boiler Number 1	27th May 2001
Boiler Number 2	31st Aug. 2001
Boiler Number 3	31st March 2002

The specifications of the boilers after conversion to husk firing are given in **Annexure 3.2**. Basic specifications of the boilers after conversion to husk firing are given below.

Specifications of Process Steam Boiler after Conversion to Husk Firing	
No. of boilers	3 (2 working and 1 stand by)
Boiler Serial Nos.	PI 3607, PI 3608 and PI 3609
Type of boiler	Atmospheric Fluidized Bed
Capacity of Each Boiler	16 TPH at 18.75 Kg/Sq. cm & 350 Degree. C, or 11 TPH at 18.75 Kg/Sq. cm & 350 Degree C And 5 TPH at 18.75 Kg/Sq. cm & 425 Degree C.

Steam Parameters	18.75 Kg. / Sq. cm, 350 Degree C.
Fuel	Rice Husk
Feed Water Temp.	140 Degree C (After economizer)
Calorific Value of Fuel	3300 –3500 kcal / kg.
Thermal Efficiency (on GCV)	83 +/- 2 %

As is evident while converting the oil-fired boilers to the husk fired boilers the steam pressures and degree to super heat of the output steam has been increased. This has led to increase in the overall efficiency.

The use of rice husk as a fuel has enabled incorporation of an economizer in the boiler, thereby increasing the overall thermal efficiency of the system.

As has been stipulated before there are plans to put a turbine of 1 MW capacity on boilers for process steam which has already been converted to husk fired boiler. The process steam boilers will then be operated in co-generation mode. The power will be sold to the other sister concerns located elsewhere. For the purpose transmission and distribution net work of PSEB will be used.

This part of the project will mitigate emission of carbon- dioxide firstly due to replacement of fossil fuel with a carbon neutral fuel for generation of process steam and secondly due to generation of power using a carbon neutral source of energy.

The project boundaries for mitigation of GHG due to process steam will be the physical boundaries of the process plant. The mitigation of GHG due to production of power (due to operation in Co-generation mode) will take place at the fossil fuel based power plants at different locations, which supply power in the state of Punjab.

The total cost of converting the boilers to husk firing has been about Rs.60 Millions. The cost of putting the turbine is additional at Rs. 20 Million. The project is being funded completely from internal cash accruals. The project apart from mitigating the emission of GHG reduces the local emissions of sulfur and other pollutants associated with the burning of fossil fuels. The project meets the development priorities of the local government of increasing the use of renewable sources of energy. The project has lead to generation of employment at the local levels for collection and supply of rice husk. The project has lead to increase in the income of the local farmers, as they are now able to get money for the agro-residue for which there was hardly any market.

Rice Husk Fired Captive Power Plant

The details regarding power requirement for operating the process plant have been provided in earlier sections of this chapter. Presently the power requirement is met by, supplies from Punjab State Electricity Board. Indian

Acrylics is converting / putting more rice-husk based boilers along with the turbo generators of aggregate capacity of 6.5 MW to meet its power requirements from captive sources. Detailed specifications of the boilers and the turbo generators are given in **Annexure 3.3** and **Annexure 3.4**. Basic specifications of the power boilers and the turbo generators are as follows:

Specifications of Power Boilers	
No. Of boilers	2 (both Operating)
Type of boiler	Atmospheric Pressure Fluidized Bed (FBC)
Capacity of Boiler	21 TPH (From and at 20 Kg. / sq. cm & 350 Degree C)
Steam Parameters	19 Kg. / Sq. cm (g), 350 Degree C.
Fuel	Rice Husk or 70 Percent Husk 30 % Straw / Bagasse
Calorific Value of Fuel	3300 k Cal / kg.
Thermal Efficiency (on GCV)	83+/-2 %
Furnace type	FBC (over bed firing)
Depth of Bed Material	220-250 mm
Connected Load	183 kW

Specifications of Turbo Generators	
Power at alternator terminals	6.5 MW
Type	Multistage, impulse, horizontal, condensing type
Inlet steam pressure	18.75 Kg./Sq. cm (g)
Inlet Steam temp.	350 Degree C.
Exhaust pressure	0.1 Ata
Inlet steam flow	40 TPH
Bleed to deaerator	4 TPH
Steam to Condenser	36 TPH
Generator Rating	8125 KVA
Power Factor	0.8
Generation	6500 kW
Generation Voltage	6600 Volts
Frequency	50 Hz.

The auxiliary power consumption for the operation of the power plant has been estimated to be about 10 percent of the gross generation. The operation of the captive rice husk based power plant will lead to mitigation of emission of carbon di-oxide, as husk is a carbon neutral fuel. The captive power project will be put up in the existing physical boundaries of the process plant. The mitigation of GHG emissions will take place in the fossil fuel based power plant, which supply power to the state of Punjab.

This part of the GHG mitigation project is presently under implementation. The plant and machinery has already been installed and the project is likely to be available for commercial use by end of September 2002. The total cost of the project has been Rs.144.5 Millions. The project is being funded completely from

internal cash accruals. The project apart from mitigating the emission of GHG will reduce the local emissions of sulfur and other pollutants associated with the burning of fossil fuels. The project meets the development priorities of the local government of increasing the use of renewable sources of energy and development of the power sector. The project will lead to generation of employment at the local levels for collection and supply of rice husk. The project will lead to increase in the income of the local farmers, as they will be able to get money for the agro-residue for which there was hardly any market. The cost of production of power at the present rice husk price of Rs. 1500 per ton will be more or less comparable to the cost of procurement of power from PSEB.

Base Line of the CDM Projects

Description of the potential CDM project has been provided in the above paragraphs of this chapter. In view of the project configurations and the operating conditions the base lines for the project has been defined. An account of the base lines considered for the project is provided in the following paragraphs.

Fuel Switching Project

The potential CDM project of converting the process steam boilers to rice husk fired boilers, mitigates emission of GHG in following two ways.

- Avoidance of use of fuel oil for production of process steam.
- Avoidance of use of fossil fuels, for generation of power by state utilities for supplying to the consumer (sister concern of Indian Acrylics).

In the absence of conversion of oil fired process steam boilers to husk fired boilers, the requirement of the process steam for operation of the plant would have been met by producing the steam in the existing oil fired boilers. Thus in case of process steam produced in the husk fired boilers, steam generation in the oil fired process boilers has been considered as the baseline. The emission of GHG in the base line scenario is the emission due to burning of oil for producing process steam in the base line scenario. The emission of GHG also takes place due to consumption of power for running the boilers in the base line scenario. This has not been considered, as even after implementation of the project power will be required to operate the boilers.

By putting up a one MW extraction type turbine on the process boilers the process steam boilers will be operated in co-generation mode. The power thus

generated will be supplied to its sister concern located at a distance using the transmission and distribution network of PSEB. In the absence of this project the sister concern would have procured this much extra power from PSEB. Thus for power generated in co-generation mode, the power fed to the grid by fossil fuel based power producing units in the state has been considered as the base line. The emission of GHG in the base line scenario will be the emission due to the operation of these power plants, which supply power to the state of Punjab.

Power Plant

Operation of rice husk fired power plant mitigates emission of green house gases due to avoidance of use of fossil fuel for generation of power by state utilities for supply of power. In the absence of rice husk based power plant Indian Acrylics would have continued to procure power from PSEB. This would have lead to the need for generation of this much extra quantity of power in fossil fuel based power plants and hence emission of GHG.

Thus in case of rice husk based power plant the base line considered is the power supply from Punjab State Electricity Board to the consumers in Punjab. The emission of GHG in the base line scenario is the emission for operation of power plants for supplying power to the consumers in Punjab.

As it is not possible to estimate the extent of emission of GHG other then carbon di-oxide only carbon di-oxide has been considered as the GHG.

Annexure 3.1
Specifications of Oil Fired Boilers

Numbers	3
Type	Wet back, Smoke Tube, 3 Pass, package
Capacity	16000 Kg. / Hr. (From and at 100 degree C)
Superheated Steam	13310 Kg. / Hr. at 225 +/- 10 degree C
Steam for Deaerator	1300 Kg. / Hr.
Design Pressure	19 Kg. / Sq. Cm (g)
Working Pressure	17 Kg. / Sq. Cm (g)
Efficiency of Boiler	88 Percent at NCV of fuel oil
Fuel	LSHS / HPS
Fuel NCV	9600 K Cal / Kg.
No. of Tube passes	Two
No. of tubes	140 in 2nd pass and 110 in 3rd pass
Length of Tubes	5.38 M in 2nd pass and 6.39 in 3rd pass
Thickness of Stay / smoke tube	6.35 mm / 3.66 mm
Max fuel consumption per boiler at rated capacity	1023 Kg. / Hr.
Internal super heater outlet Temperature	225 + / - 10 Degree C
Feed Pumps Flow Rate	55 Cubic Meters / Hr.
Fuel Oil Pump Type	Screw Type
Fuel Oil Flow Rate	1000 Liters / Hr.
Oil Pre heater	Steam Tracing Type (Thermostatic Controls)
Steam Consumption for Oil pre heating	240 Kg. / Hr.
Burner Type	Pressure Jet Spill Return
No. Of burners per boiler	Two
Rated Capacity of Each Burner	600 Kg. / Hr.
Burner Turndown Ratio	1:4
Controls	Electro- mechanical, servo motor
Flame Diameter X Length	900X4500 mm
FD Fan Type	Centrifugal
FD Fan Capacity	8500 N meter cube per hr.
Head	400 mm wg
Motor HP	30
No. of Fans	2 per boiler both working

Annexure 3.2
Specifications of Process Steam Boiler after Conversion to Husk Firing

No. of boilers	3 (2 working and 1 stand by)
Type of boiler	Atmospheric Fluidized Bed
Capacity of Each Boiler	16 TPH at 18.75 Kg/Sq. cm & 350 Degree. C, 18 TPH at 100 Degree. C
Steam Pressure	18.75 Kg. / Sq. cm
Steam Temp.	350 Degree C.
Fuel	Rice Husk
Feed Water Temp.(After economizer)	140 Degree C
Calorific Value of Fuel	3300 –3500 kcal / kg.
Thermal Efficiency (on GCV)	83 +/- 2 %
Bed Temperature	825+/-25 Degree. C
Flue gas temp. After boiler	300+/-10 Degree C.
Flue gas temp. After APH	160+/-10 Degree C.
Hot air temp. After APH	110+/-10 Degree C.
Flue gas temp. After Trema	120+/-5 Degree C.
Heating surface Area of Furnace Tubes	90 Sq. M
Heating Surface Area of Convection Zone (Boiler drum)	556 Sq. M
Heating Surface Area of Super Heater	40 Sq. M
Heating Surface Area of Air Pre-heater	270 Sq. M
Heating Surface Area of Economizer	80 Sq. M
Furnace type	FBC (over bed firing)
Furnace Area	6 Sq. M
Draught in Furnace	-2 to –5 mm WC
Depth of Bed Material	220-250 mm
Connected Load FD Fan	2 Nos. 22 kW each
Connected Load ID Fan	1No. 56 kW each
Connected Load Fuel Feeder	2 Nos. 1 kW Each
Connected Load Rotary air lock	8 Nos. 0.75 kW eac
Connected Load Husk screen	2 Nos. 1.5 kW each
Connected Load Husk Conveyor	2 Nos. 1.5 kW each
Connected Load Ash Conveyor	2 Nos. 2.25 kW ea

Annexure 3.3
Specifications of Power Boilers

No. Of boilers	2
Type of boiler	Atmospheric Fluidized Bed
Capacity of Boiler	21 TPH
Steam Parameters	
Steam Pressure	19 Kg. / Sq. cm
Steam Temp.	350 Degree C.
Fuel	Rice Husk or Coal or 70 Percent Husk 30 % Straw / Bagasse
Calorific Value of Fuel	3300 kcal / kg.
Thermal Efficiency (on GCV)	83+/-2 %
Temp.- Bed	825+/-25 Degree. C
Flue gas temp. Afar boiler	300+/-10 Degree C.
Flue gas temp. After APH	160+/-10 Degree C.
Hot air temp. After APH	110+/-10 Degree C.
Heating Surface Furnace Tubes	130 Sq. M
Heating Surface Convection Zone (Boiler drum)	722 Sq. M
Heating Surface Super Heater	60 Sq. M
Heating Surface Air Pre-heater	324 Sq. M
Heating Surface Economizer	175.5 Sq. M
Furnace type	FBC (over bed firing)
Draught in Furnace	-2 to –5 mm WC
Depth of Bed Material	220-250 mm
Connected Load - FD Fan	2 Nos. 30 kW each
Connected Load - ID Fan (I)	1No. 75 kW each
Connected Load - ID Fan (II)	1No. 30 kW each
Connected Load – Fuel Feeder	4 Nos. 1 kW Each
Connected Load – Rotary ash air lock	4 Nos.0.75 kW each
Connected Load – Rotary cyclone air lock.	3 Nos. 0.75 kW each
Connected Load – AHP Rotary air lock	2 Nos. 0.75kW Each
Connected Load – Husk screen	2 Nos. 1.5 kW each
Connected Load – Husk Conveyor	2 Nos. 1.5 kW each
Connected Load – Ash Conveyor	2 Nos. 2.25 kW each

Annexure 3.4
Specifications of Turbo Generators

Power at alternator terminals	6.5 MW
Type	Multistage, impulse, horizontal, Condensing type
Rated Speed of Turbine	8250 RPM
Gearbox output speed	1500 RPM
Inlet steam pressure	18.75 Kg./Sq. cm (g)
Inlet Steam temp	350 Degree C.
Exhaust pressure	0.1 Ata
Inlet steam flow	40 TPH
Bleed to deaerator	4 TPH
Steam to Condenser	36 TPH
Generator Type	Brushless excitation
Rating	8125 KVA
Power Factor	0.8
Power Generation	6500 kW
Generation Voltage	6600 Volts
Generation Frequency	50 Hz.
Alternator Speed	1500 RPM
Auxiliary Power Requirement	
Auxiliary Power Requirement -Air blower motor	1.5
Auxiliary Power Requirement -Vapor extraction	1.1
Auxiliary Power Requirement -Auxiliary Oil Pump Motor	20
Auxiliary Power Requirement -CEP Motor I	20
Auxiliary Power Requirement -CEP Motor II	20
Auxiliary Power Requirement -Bearing Gear Motor	25
Auxiliary Power Requirement -Generator Heater	3.2
Auxiliary Supply for Panel	4

4 Emissions in the Base Line Scenario

As has been stipulated in earlier sections of the report three different base lines has been considered for different components of the potential CDM project.

In case of steam produced in the process boilers, steam generation in the oil fired process boilers has been considered as the baseline. The emission of GHG in the base line scenario is the emission due to burning of oil for producing process steam in the base line scenario.

For power supplied to other sister concerns, power fed to the grid by fossil fuel based power plants in the state has been considered as the base line. The emission of GHG in the base line scenario will be the emission due to operation of these power plants, which supply power to the state of Punjab.

In case of rice husk based power plant base line considered is power supply from Punjab State Electricity Board to the consumers in Punjab. Emission of GHG in the base line scenario is the emission for operation of fossil fuel based power plants for supplying power to the consumers in Punjab.

As it is not possible to estimate the extent of emission of GHG other then carbon di-oxide only carbon di-oxide has been considered as the GHG.

In the following paragraphs details regarding the operating conditions in the base line scenarios has been provided. The emission of carbon di-oxide in the base line has also been estimated and provided in the following paragraphs.

Emission of GHG Due to Power Generation & Supply

The emission of GHG for generation of power takes place due to combustion of fossil fuels in thermal power plants. The GHG emission intensity of various power plants is different due to difference in the operating heat rates, fossil fuel used, difference in the auxiliary power consumption in different power plants. Thus to estimate the emission of GHG in the base line scenario it is imperative to examine the contribution by different power plants towards the overall supply of power in the state of Punjab. The operating parameters like heat rates, fuel used and auxiliary power consumption of the contributing power plants is also required to be examined.

Punjab State Electricity Board (PSEB) has the mandate for generation, distribution and supply of power in the state of Punjab. PSEB has its own power

plants for generation of power. It also procures power from central sector power plants to supply it in the state. The transmission and distribution network in the state is owned by PSEB. Details of the total installed capacity available with PSEB for meeting the power requirements are given in **Table 4.1** below.

Table 4.1 Unit Wise Source of Power in Punjab - 1999-2000

(Capacity in MW)

B	Own Hydro Projects	
B.1	Shanan	60
B.2	Shanan Extn.	50
B.3	UBDC Ph. I	45
B.4	UBDC Ph. II	46
B.5	Mukerian Hydro	207
B.6	Anandpur Sahib Hydro	134
B.7	Nidampur Micro Hydal	1
B.8	Daudhar Micro hydal	2
B.9	Thuhi Micro Hydal	1
B.10	Rohti Micro Hydal	1
B.11	Ranjit Sagar Dam HEP	600
	Total B	1147
C	PSEB Thermal Power	
C.1	GNDTP Bhatinda	440
C.2	GGSSTP (Stage I) Ropar	420
C.3	GGSSTP (Stage II) Ropar	420
C.4	GGSSTP (Stage III) Ropar	420
C.5	GHTP Lehra Mohabat **	420
	Total C	2120
D	RSTP	10
I	Hydal Power Houses of PEDA	
I.1	Chupki	2
I.2	Narangwal	2
I.3	Tugal	2
I.4	Dalla	2
	Total I	8

Source: PSEB Planning Department

As mentioned before apart from generating its own power an allocation has been made from central sector power projects towards supply of power to the state of Punjab. The details of the central sector power projects from which allocation to PSEB has been made are provided in **Table 4.2** below.

Table 4.2: Allocation of Capacity from Central Sector Power Plants to Punjab: 1999-2000

(Figures in MW)

		Capacity	Share of Punjab
A	**Share from Common Pool Hydro Projects**		
A.1	Bhakra Nangal Complex	1200	731
A.2	Dehar Power House	1145	475
A.3	Pong Power House	360	91
	Total A	2705	1297
E	**Share from Central Hydal Projects**		
E.1	Salal - I	690	112
E.2	Salal - II		53
E.3	Baira Suil	180	84
E.4	Tanakpur	120	14
E.5	Chamera	540	108
E.6	Uri	480	66
	Total E	2010	437
F	**Share From Central Thermal Projects**		
F.1	Rihand	1000	110
F.2	Singrauli	2000	200
F.3	Unchahar - I	420	36
F.4	Unchahar - II		60
F.5	Dadri NCTPS	840	
	Total F	4260	406
G	**Share From Central Gas Based Projects**		
G.1	Anta	413	32
G.2	Auriya	655	82
G.3	Dadri	816	130
	Total G	1884	244
H	**Share From Central Atomic Power Projects**		
H.1	Narora	455	90
H.2	RAPP - A	320	28
H.3	RAPP - B		
	Total H	775	118

Source: Northern Region Electricity Board

As is evident from the Tables above, the total capacity available for supply of power to the state of Punjab in the year 1999-2000 was 5787 MW. This capacity comprised of generation of power from hydro, coal, gas/naphtha and nuclear energy sources in the following proportions:

	Capacity (MW)	Percent Share
Hydro	2889	49.9
Gas Turbine	244	4.2
Nuclear	118	2.0
Coal Based Thermal	2536	43.8
Total	**5787**	**100.0**

Data regarding production of power and performance parameters for the power plants in the state of Punjab are given in **Table 4.3** below.

Table 4.3: Performance of Power Plants of Punjab: 1999-2000

(Figures in Million Units)

		Generation	Auxiliary Consumption	Net Generation
B	**Own Hydro Projects**			
B.1	Shanan	506		
B.2	Shanan Extn.			
B.3	UBDC Ph. I	319		
B.4	UBDC Ph. II			
B.5	Mukerian Hydro	1547		
B.6	Anandpur Sahib Hydro	837		
B.7	Nidampur Micro Hydal			
B.8	Daudhar Micro hydal	11		
B.9	Thuhi Micro Hydal			
B.10	Rohti Micro Hydal			
B.11	Ranjit Sagar Dam HEP	0	0	0
	Total B	3220	6	3214
C	**PSEB Thermal Power**			
C.1	GNDTP Bhatinda	2659	260	2399
C.2	GGSSTP (Stage I) Ropar			
C.3	GGSSTP (Stage II) Ropar	8203	664	7539
C.4	GGSSTP (Stage III) Ropar			
C.5	GHTP Lehra Mohabat	2969	266	2703
	Total C	13831	1190	12641
D	**RSTP**	0	0	0

Source: PSEB/Northern Region Electricity Board

The details regarding performance of central sector power projects, which supply power to Punjab, are given in **Table 4.4** below.

Table 4.4: Performance of Central Sector Power Plants Supplying Power to Punjab. 1999-2000

		Capacity	Share of Punjab	Generation	Auxiliary Consumption.	Net Generation	Supply To PSEB
		(MW)	(MW)	(MUs)	(MUs)	(MUs)	(Mus)
A	**Common Pool Hydro**						
A.1	Bhakra Complex	1200	731	6944	383	6561	2666
A.2	Dehar Power House	1145	475	3014	176	2838	1314
A.3	Pong Power House	360	91	2024	134	1890	471
	Total A	2705	1297	11982	693	11289	4451
E	**Hydal Projects**						
E.1	Salal - I	690	112	3249	64	3185	844
E.2	Salal - II		53				
E.3	Baira Suil	180	84	425	31	394	183
E.4	Tanakpur	120	14	407	17	390	59
E.5	Chamera	540	108	2126	99	2027	398

E.6	Uri	480	66	1949	45	1904	218
	Total E	2010	437	8156	256	7900	1702
F	**Thermal Projects**						
F.1	Rihand	1000	110	7607	839	6768	687
F.2	Singrauli	2000	200	16505	1620	14885	1521
F.3	Unchahar - I	420	36	3153	379	2774	135
F.4	Unchahar - II		60	454	59	395	57
F.5	Dadri NCTPS	840		7092	544	6548	50
	Total F	4260	406	34811	3441	31370	2450
G	**Gas Based Projects**						
G.1	Anta	413	32	3180	185	2995	287
G.2	Auriya	655	82	5078	254	4824	543
G.3	Dadri	816	130	5116	109	5007	582
	Total G	1884	244	13374	548	12826	1412
H	**Atomic Power**						
H.1	Narora	455	90	3125	416	2709	186
H.2	RAPP - A	320	28	2191	187	2004	0
H.3	RAPP - B			13	3	10	0
	Total H	775	118	5316	603	4713	186

Source. Northrn Region Electricity Board

Based on above the break up of the total supply of power to Punjab in terms of source and the fuel for the year 1999-2000 has been worked out to be as given in **Table 4.5** below.

Table 4.5: Source Wise & Fuel Wise Break Up Power Supply - Punjab, 1999-2000

	Capacity (MW)		**Supply (Million Units)**	
	Allocated / Effective Capacity	**Percent Distribution**	**Supply at the bus bar**	**Percent Distribution**
State				
Hydro	1155	19.96	3230.2	12.39
Gas	0	0.00	0	0.00
Nuclear	0	0.00	0	0.00
Coal Based Thermal	2130	36.81	12641	48.48
Centre				
Hydro	1734	29.96	6153	23.60
Gas	244	4.22	1412	5.42
Nuclear	118	2.04	186	0.71
Coal Based Thermal	406	7.02	2450	9.40
Total				
Hydro	2889	49.92	9383.2	35.99
Gas	244	4.22	1412	5.42
Nuclear	118	2.04	186	0.71
Coal Based Thermal	2536	43.82	15091	57.88

Punjab has an efficient network for transmission and distribution of power through out the state to ensure a steady supply of power. To meet contingencies arising as a result of an occasional shortage of power, the network is connected to the national grid.

As has been mentioned before carbon di-oxide is the only GHG considered, as it is not possible to estimate the emission of other GHG for production of power. This is in view of the availability of data regarding emission of other GHG for generation of power. For estimating emission intensity of fossil fuel based power plants characteristics of different fuels used is considered to be as given in **Table 4.6** below.

Table 4.6: Charactenstics of Fossil Fuels used in Power Plants

Naphtha	
Carbon content by Wt.	80 Percent
Calorific value	10750 K Cal / Kg.
Percent Oxidization	99 Percent
Natural Gas	
Carbon Content by Wt.	75 Percent
Calorific Value	12300 K Cal / Kg.
Percent Oxidization	99.5 Percent
Coal	
Carbon Content	40 Percent
Calorific Value	3600 K Cal / Kg.
Percent Oxidization	98 Percent

Table 4.7 below provides the heat rates and carbon emission intensity of fossil fuel based power plants, which supply power to the state of Punjab.

Table 4.7: Heat Rates and GHG emission Intensity of Fossil Fuel Based Power Plants - Punjab

		Gene. Million Units	Aux. Cons Million Units	Net Gene. Million Units	Heat Rate K Cal/ kWh	Carbon Burned Million Kg.	Carbon Burned Per kWh to bus Kg.
A	**Share from Common Pool Hydro Projects**						
A 1	Bhakra Nangal Complex	6944	383	6561	0	0	0
A.2	Dehar Power House	3014	176	2838	0	0	0
A.3	Pong Power House	2024	134	1890	0	0	0
	Total A	11982	693	11289	0	0	0
B	**Own Hydro Projects**						
B.1	Shanan	506			0	0	0
B.2	Shanan Extn.				0	0	0
B.3	UBDC Ph. I	319			0	0	0
B 4	UBDC Ph. II				0	0	0
B.5	Mukerian Hydro	1547			0	0	0
B.6	Anandpur Sahib Hydro	837			0	0	0
B 7	Nidampur Micro Hydal				0	0	0
B 8	Daudhar Micro hydal	11			0	0	0
B 9	Thuhi Micro Hydal				0	0	0
B.10	Rohti Micro Hydal				0	0	0
B.11	Ranjit Sagar Dam HEP	0	0	0	0	0	0
	Total B	3220	6	3214 xx		0	0

C	**PSEB Thermal Power**						
C.1	GNDTP Bhatinda xx	2659	260	2399	3053	884	0.3685
C.2	GGSSTP (Stage I) Ropar						
C.3	GGSSTP (Stage II) Ropar xx	8203	664	7539	2810	2510	0.3329
C.4	GGSSTP (Stage III) Ropar						
C.5	GHTP Lehra Mohabat xx	2969	266	2703	3010	973	0.3600
	Total C	13831	1190	12641 xx		4367	0.3455
D	**RSTP**	0	0	0	0		
E	**Share from Central Hydal Projects**						
E.1	Salal - I	3249	64	3185	0	0	0
E.2	Salal - II				0	0	0
E.3	Baira Suil	425	31	394	0	0	0
E.4	Tanakpur	407	17	390	0	0	0
E.5	Chamera	2126	99	2027	0	0	0
E.6	Uri	1949	45	1904	0	0	0
	Total E	8156	256	7900	0	0	0
F	**Share From Central Thermal Projects**						
F.1	Rihand @	7607	839	6768	2483	2057	0.3039
F.2	Singrauli @	16505	1620	14885	2650	4763	0.3200
F.3	Unchahar - I #	3153	379	2774	2500	858	0.3094
F.4	Unchahar - II #	454	59	395	2500	124	0.3129
F.5	Dadri NCTPS #	7092	544	6548	2500	1931	0.2948
	Total F	34811	3441	31370 Xx		9732	0.3102
G	**Share From Central Gas Based Projects**						
G.1	Anta	3180	185	2995	2100	405	0.1353
G.2	Auriya	5078	254	4824	2100	647	0.1341
G.3	Dadri	5116	109	5007	2100	652	0.1302
	Total G	13374	548	12826 Xx		1704	0.1329
H	**Share From Central Atomic Power Projects**						
H.1	Narora	3125	416	2709	0	0	0
H.2	RAPP - A	2191	187	2004	0	0	0
H.3	RAPP - B	13	3	10	0	0	0
	Total H	5316	603	4713 Xx		0	0
I	**Hydal Power Houses of PEDA**						
I.1	Chupki				0	0	0
I.2	Narangwal				0	0	0
I.3	Tugal				0	0	0
I.4	Dalla				0	0	0
	Total I				0	0	0

Notes:

xx Heat rates as per PSEB planning department.

@ Old Heat Rates as per CEA current figures not available.

Heat Rates not available. Heat rates has been considered as per the standard rate allowed by CEA.

Based on the GHG emission intensity of individual fossil fuel based power plant and the contribution by the individual power plant, the GHG emission for generation of power in the state of Punjab in the year 1999-2000 has been worked out to be as given in **Table 4.8** below.

Table 4.8: Aggregate Emission of GHG - Power Sector - Punjab

		Supply To PSEB 99-2000 Million Units	Carbon Burned Per kWh to bus Kg.	Carbon Burned for Supply to PSEB Million Kg	CO2 Emiss. for supply to PSEB Million Kg
A	**Common Pool Hydro Projects**				
A.1	Bhakra Nangal Complex	2666	0	0	0
A.2	Dehar Power House	1314	0	0	0
A.3	Pong Power House	471	0	0	0
	Total A	4451	0	0	0
B	**Own Hydro Projects**				
B.1	Shanan		0	0	0
B.2	Shanan Extn.		0	0	0
B.3	UBDC Ph. I		0	0	0
B.4	UBDC Ph. II		0	0	0
B.5	Mukenan Hydro		0	0	0
B.6	Anandpur Sahib Hydro		0	0	0
B.7	Nidampur Micro Hydal		0	0	0
B.8	Daudhar Micro hydal		0	0	0
B.9	Thuhi Micro Hydal		0	0	0
B.10	Rohti Micro Hydal		0	0	0
B.11	Ranjit Sagar Dam HEP	0	0	0	0
	Total B	3214	0	0	0
C	**PSEB Thermal Power**				
C.1	GNDTP Bhatinda	2399	0.3685	884	3241
C.2	GGSSTP (Stage I) Ropar				
C.3	GGSSTP (Stage II) Ropar	7539	0.3329	2510	9204
C.4	GGSSTP (Stage III) Ropar				
C.5	GHTP Lehra Mohabat	2703	0.3600	973	3569
	Total C	12641		4367	16014
D	**RSTP**	0			
E	**Central Hydal Projects**				
E.1	Salal - I	844	0	0	0
E.2	Salal - II		0	0	0
E.3	Baira Suil	183	0	0	0
E.4	Tanakpur	59	0	0	0
E.5	Chamera	398	0	0	0
E.6	Uri	218	0	0	0
	Total E	1702	0	0	0
F	**Central Thermal Projects**				
F 1	Rihand	687	0.3039	209	766
F 2	Singrauli	1521	0.3200	487	1785
F 3	Unchahar - I	135	0.3094	42	153
F 4	Unchahar - II	57	0.3129	18	65
F 5	Dadri NCTPS	50	0.2948	15	54
	Total F	2450		770	2823

G	Central Gas Based Projects				
G.1	Anta	287	0.1353	39	142
G.2	Auriya	543	0.1341	73	267
G.3	Dadri	582	0.1302	76	278
	Total G	1412		187	687
H	Central Atomic Power Projects				
H.1	Narora	186	0	0	0
H.2	RAPP - A	0	0	0	0
H.3	RAPP - B	0	0	0	0
	Total H	186	0	0	0
I	Hydal Power Houses of PEDA				
I.1	Chupki		0	0	0
I.2	Narangwal		0	0	0
I.3	Tugal		0	0	0
I.4	Dalla		0	0	0
	Total I	16	0	0	0

The total emission of GHG for supplying power to the distribution grid of PSEB in the year 1999-2000 was 19524 million Kg of carbon di-oxide. Total power supplied to the grid in the same period was 26072 million units, out of which 16503 million units were supplied by the fossil fuel based power plants and the balance was supplied by the power plants based on other sources of energy. Thus the emission of GHG for supplying one unit of fossil fuel based power to the grid has been estimated to be 1.1831 Kg of carbon di-oxide. The emission of GHG for supplying one unit of power at an aggregate level has been 0.7489 Kg of carbon di-oxide.

The transmission and distribution losses in the state of Punjab for the year 1999-2000 were 17.25 percent. The power to large industries like Indian Acrylics is supplied in high traction form. Most of the losses in the transmission and distribution of power takes place for transmission and distribution in low traction form. Thus the transmission and distribution losses in the HT form has been considered at 5 percent. Based on the above the emission of CO2 for every unit of fossil fuel based power supplied to Indian Acrylics in the year 1999-2000 has been worked out to be 1.2454 Kg. The emission of GHG for supplying power to Indian Acrylics at an aggregate level has been estimated to be 0.7883 Kg., of carbon di-oxide per unit of power.

Thus the emission of GHG in the base line scenario for generation and supply of power to consumers in Punjab for the year 1999-2000 has been estimated to be as given in **Table 4.9** below:

Table 4.9: Power Supply and Emission of GHG in Punjab: 1999-2000

Total power supply to PSEB grid	26072	Million Units
Fossil fuel based power supply to PSEB grid	16503	Million Units
Transmission & distribution loss (in HT)	5.00	Percent
Emission of CO2 for power supply to grid of PSEB	19524	Million Kg.
CO2 emission for power supply to grid	0.7489	Kg. / kWh
CO2 emission for fossil fuel based power supply to grid	1.1831	Kg. / kWh
CO2 emission for power supply to consumers	0.7883	Kg. / kWh
CO2 emission for fossil fuel based power supply to consumers	1.2454	Kg. / kWh

Emission of GHG for Generation of Process Steam

As mentioned before in case of steam produced in the process boilers, steam generation in the oil fired process boilers has been considered as the baseline. The emission of GHG in the base line scenario is the emission due to burning of oil for producing process steam in the base line scenario. Mitigation of GHG due to the project under consideration is taking place due to fuel switching from fuel oil to rice husk for Process Steam Boilers. To estimate emission of carbon dioxide in the baseline scenario in case of rice husk based process steam boilers, the factors considered are as follows:

- Specifications of the oil fired boilers used earlier
- Thermal efficiency of oil fired boilers

The specifications of the oil-fired boilers have already been discussed in chapter three of the report. The capacity of each of the oil fired process steam boiler was 16 tons per hour (from and at 100 degree C). A heat and material balance for the oil-fired boilers in actual working conditions has been carried out to determine the consumption of fuel and production of steam at actual working conditions. For details of the heat and material balance please refer the diagram provided below.

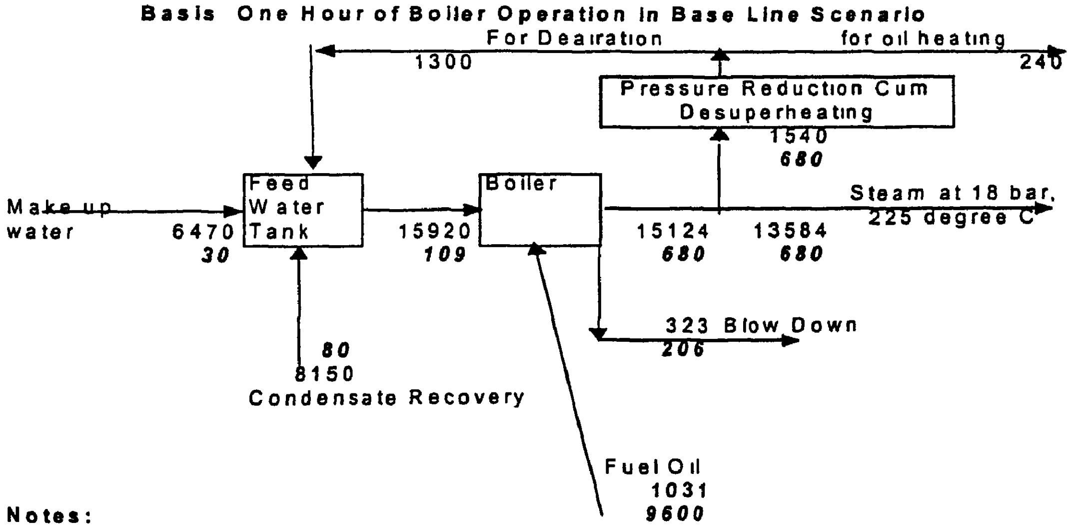
Based of heat balance and material balance of the steam generation system used in the base line scenario, it has been worked out that for every ton of process steam out of the steam generation system the consumption of fuel oil will be 75.9 kg Apart from this some quantity of fuel oil was being used for converting part of the process steam at 225 deg. C to super heated steam at 425 degree C. The thermal efficiency of the oil fired steam super heater is much less then that of the process boilers. Considering thermal efficiency of 75 percent the requirement of fuel oil for superheating one ton of process steam from 225 deg. C to 425 degree C has been estimated to be 15 Kg. This has been calculated

considering the heat content of super haeted steam at 790 K Cal / Kg and the calorific value of fuel at 9600 K cal / Kg.

The emission of carbon di-oxide due to combustion of fuel oil have been worked out considering 80 percent carbon content in the oil by weight and 99 percent oxidization level of carbon in the oil. The emission of carbon di-oxide due to fuel oil for every ton of process steam produced at 18 Kg. / Sq. Cm and 225 degree C has been estimated to be 220.43 Kg of carbon di-oxide. The emission of carbon di-oxide for generation of steam at 18 Kg / Sq. Cm and 425 degree C is estimated to be 263.99 Kg of carbon di-oxide per ton of steam.

HEAT AND MATERIAL BALANCE

Basis One Hour of Boiler Operation In Base Line Scenario



Notes:
Figures give mass flow rate in Kg / Hr
Figures indicated as *xxxx* give the heat content in K Cal per Kg

Assumptions:
Condensate recovery = 60 Percent at 80 degree C
Boiler Blow Down = 5 Percent of feed water make -up
Thermal Efficiency of boiler = 88 Percent

Apart from combustion of fuel oil the emission of GHG in the base line scenario also takes place due to consumption of power for operation of the process steam generation facilities. Power is consumed for operation of feed water pump, oil pump, condensate recovery pump and the ID fan. This factor has not been considered, as power will be required even after implementation of the project of fuel switching.

Emission of GHG after the Projects

Fuel Switching

For generation of process steam after conversion of boilers to husk fired boilers some quantity of fuel oil is still used to maintain the flame from time to time. Thus even after implementation of the project of conversion of oil fired boilers to husk fired boilers there will be some emission of GHG. To determine mitigation of emission of GHG after implementation of the project this factor is required to be taken care of.

Power Generation

For generation of power in the captive power plant using rice husk as the fuel some quantity of fuel oil will be used to maintain the flame from time to time. Thus even after implementation of the project of rice husk based captive power plant there will be some emission of GHG. To determine mitigation of emission of GHG after implementation of the project this factor is required to be kept in mind.

Quantum of CERs

Mitigation of GHG due to the project has been estimated to be as follows:

For power supplied to other concerns	1.1831 kg of carbon di-oxide per unit of power supplied to grid
For power used with in the process plant.	1.2454 kg of carbon di-oxide per unit of net power produced in the captive power plant
For process steam produced in the process boilers after switching the fuel from fuel oil to rice husk	220.43 kg of carbon di-oxide per ton of steam produced at 18 bar pressure and 225 degree C
	264 Kg of carbon di-oxide per ton of steam produced at 18 bar pressure and 425 degree C

Present norms of consumption of utilities in the process plant are as follows:

Process Steam	4464 Thousand K Cal per ton of acrylic fibers
Power	1296 units per ton of acrylic fibers

Superheated steam at 425 degree C and the steam at 225 degree C are used in the ration of 5:22. Thus it has been estimated that the process steam at 425 degree C and 225 degree C, required for production of one ton of fiber will be 1.3 tons and 6.9 tons respectively.

The capacity of the process plant is 36000 tons per annum of fibers. Considering total power generation capacity of 7.5 MW. The actual generation of power net of auxiliary consumption (considering PLF of 90 percent and auxiliary consumption of 10 percent) will be about 53.2 million units per annum. About 47 million units will be used in house in the process plant and the balance will be supplied to other concerns. Thus GHG mitigation potential of the project is estimated to be as follows:

Due to power supplied to other concerns	6200 kWh*1.1831 =	7335 tons of CO2 per annum
Due to captive power consumption	47000 kWh*1.245 =	58515 tons of CO2 per annum
Due to generation of process steam at 225 degree C	6.9*36000*220.43/1000 =	54755 tons of CO2 per annum
Due to generation of process steam at 425 degree C	1.3*36000*264/1000 =	12355 tons of CO2 per annum
Total		132960 tons of CO2 per annum

The two potential CDM projects put together has the potential of mitigating the emission of GHG to the extent of about 133 thousand tons per annum, at 100 percent capacity utilization of the process plant. This is after considering that the project will be able to meet the utility requirements of the process plant completely. In actual practice process plant will not operate at 100 percent of its capacity. Thus the actual generation of CERs will be much less then 133 thousand numbers per annum.

5 Possibilities for Monitoring and Verification

Based on the emission factors under the base line scenario and the capacity of the plant it has been estimated that the number of CERs that can be generated at 100 percent capacity utilization will be 133 thousand numbers per annum. The actual number of CERs that will be generated in actual practice will be much less and will depend upon the capacity utilization of the process plant and working of the project. The use of fuel oil to support the working of the husk fired process boilers and husk-based power plant is also required to be taken care of.

To determine the actual mitigation of GHG due to the potential CDM project, it is required that the actual working of the project be monitored.

The project is being implemented at the existing site of Indian Acrylics Limited. As three different base lines has been established for the project, monitoring and verification of the CERs due to the project will be required to be done separately for the three cases.

:aptive Power Consumption

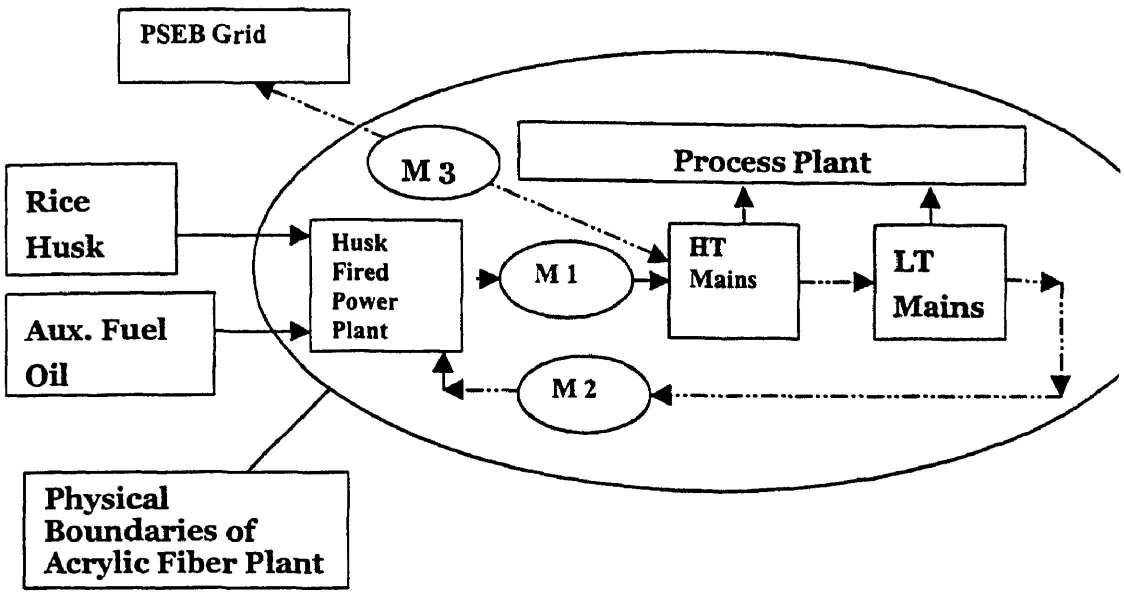
Generation of power for captive consumption using rice husk as fuel will lead to mitigation of GHG in the fossil fuel based power plants, which supply power to Punjab State. Such fossil fuel based power plants are located within the state as well as outside the state.

As is evident mitigation of GHG due to production of power in the rice husk fired power plant is spread over large geographical areas. The area where mitigation of GHG takes place is much beyond the physical boundaries of the site. In-spite of this it is possible to monitor the mitigation within the physical boundaries of the process plant. This is so as a fixed base line throughout the crediting period is being used. The emission of GHG in the base line scenario has been determined for every unit of power produced. The mitigation of GHG for every unit of net power generated for captive consumption in husk fired power plant has been estimated. These norms regarding mitigation of GHG for every unit of net power generated will be used through out the crediting period of ten years.

For developing the methodology for monitoring and verification, the configuration and arrangements of the Project along with the project boundaries has been considered. The monitoring and verification of GHG mitigation and the quantum of CERs generated is proposed to be done by measuring the net power fed by the captive power plant to the distribution system of the process plant.

Even after creation of captive facilities for generation of power the process plant will be connected to the distribution grid of PSEB. It is proposed that some power will be drawn from the grid to account for the minimum load. This will also help to take care of critical load of the plant. Under the present operating arrangements, some of the critical equipment is connected through rotary UPS (uninterrupted power supply based on diesel generators). This is to ensure operation of the critical equipment in case of a power failure. This arrangement is likely to continue even after implementation of the captive power plant.

In order to monitor mitigation of GHG due to generation of power in husk fired power plant it is required that, net power supplied to the distribution system of the process plant be measured. It is proposed that a two-way meter be installed to measure the power fed to the distribution system of the process plant. A separate meter will measure the auxiliary power used for operation of the process plant. Difference of the readings in the two meters will provide the quantum of net power generated. Net power generated less the quantum of power exported to the grid as determined by a separate two way meter will provide net power supplied to the distribution system of the process plant. Net power supplied to the process plant multiplied by the mitigation of GHG for every unit of net power supplied as worked out in the earlier chapter will provide the number of CERs generated over a period of time. Out of this the emission of carbon di-oxide due to use of auxiliary oil is required to be subtracted. This is depicted schematically in the following diagram.



M 1 = Meter One
M 2 = Meter Two
M 3 = Meter Three (Two way meter)
P (Net Power Supplied) = Reading in M 1 in thousand kWh – Reading in M2 in thousand kWh- Reading in M3 in thousand kWh
CERs = (P*1.2454) – (Aux. Oil Consumption in tons * 0.8*0.99*3.667) Numbers

Power Supplied to Other Units

For power supplied to other units, power feed to the grid by the power producing units in the state has been considered as the base line. Emission of GHG in the base line scenario will be the emission due to operation of fossil fuel based power plants, which supply power to the state of Punjab. The mitigation of GHG will take place at the fossil fuel based power plants that supply power to the state of Punjab. Monitoring and verifications of mitigation of GHG can be done within the premises of the process plant as a fixed base line is being used. Emission of carbon di-oxide in the base line scenario for supplying HT power to the consumers in the state has been estimated to be 1.8131 kg for every unit of power. This norm is proposed to be used through out the crediting period of the potential CDM project.

Monitoring and verification of CERs due to export of power may be done based on the quantum of power feed to the distribution grid of PSEB. The power fed to the distribution grid of PSEB for onward transmission to the sister concern may be measured using an energy meter.

Process Steam

In case of steam produced in the process boilers, steam generation in the oil fired process boilers has been considered as the baseline. The emission of GHG in the base line scenario is the emission due to burning of oil for producing process steam in the base line scenario.

The extent of actual mitigation of GHG may be determined by determining the quantum of process steam generated. The monitoring of GHG mitigation in case of production of process steam may done by measuring the quantum of process steam by using the steam flow meters at the out let of each boiler.

As the steam produced in the process boilers will be used in co-generation mode, there may be conditions when a part of the steam generated in the process boilers after expansion in the turbine will be condensed. Further there are three process boilers out of which two will be working at a time and one will be stand by. Depending upon the need the stand by process boiler may be used to feed the steam to the turbine of the power plant. Thus it is necessary that the generation and use of steam for heating applications be checked with the norms of consumption of process steam, (per ton of production of acrylic fibers). GHG mitigation benefits due to switching the fuel from fuel oil to rice husk should be given on the least of the quantum of process steam determined by the two methods.

The norms of consumption of process steam and power in the process plant for production of acrylics fibers has been worked out based on the past consumption pattern for utilities. Process plant in which the potential CDM project is being put has been in operation since last nine years. It has well established norms regarding consumption of utilities for production of acrylic fibers. Thus the generation and consumption of process steam and power in the plant being measured to determine the number of CERs can be cross-verified, with the production of acrylic fibers.

As per the norms of the technology supplier the requirement of process steam and power for production of acrylic fiber were as follows:

Process Steam	9.50 tons / ton of fiber
Electricity	1975 Units / ton of fiber

Over a period of time Indian Acrylics has carried out some modifications and alterations in the process plant with the objective of reducing the energy intensity of production of fibers The interventions include replacement of vapor compression refrigeration with vapor absorption refrigeration and incorporation

of an additional stage in the solvent recovery cycle. With the replacement of vapor compression refrigeration with vapor absorption refrigeration the consumption of power has reduced but the consumption of process steam has increased slightly. With the incorporation of an additional stage in the solvent recovery cycle the consumption of process steam has reduced.

Due to the interventions to reduce energy intensity for production of fibers, the present norms of consumption for process steam and electricity has under gone change. Based on actual production of acrylic fibers and consumption of fuels and power over last two years the norms of consumption have been worked out. Details of the workings are provided in **Annexure 5.1**.

The norms of consumption of power and process heat per ton of production of fiber in the past and at present are given in **Table 5.1**.

Table 5.1: Norms of Consumption of Utilities for Producing Acrylic Fibers

(Consumption Per MT of Fiber)

Time Frame	Power (kWh)			Heat (Ths. Kcal)		
	Avg.	High	Low	Avg.	High	Low
Present Status	1296	106%	91%	4464	104%	94%
Before Commissioning of Extra Effect in Solvent recovery & Vapor Absorption Chillers	1413	104%	88%	4558	104%	90%
After Commissioning of Extra Effect in Solvent Recovery & before Vapor Absorption Chiller	1437	105%	92%	3758	111%	76%
After Comm. Of Extra Effect in Solvent Recovery and Vapor Absorption Chillers	1280	107%	90%	4739	103%	95%

Notes:

1. Only that data set has been considered where the capacity utilization was 80 Percent or more. The consumption will increase in case of lower capacity utilization.
2. High and low indicates percentage of the average values.
3. For details of the workings please see Annexure - 5.1

Emission of GHG in the base line scenario for generation of process steam has already been discussed in earlier chapter of this report. Based on the production of acrylic fibers the emission of GHG in the base line scenario can be determined by using the norms of consumption for utilities as provided in **Table 5.1** above. The emission of GHG after implementation of the potential CDM project can be determined by taking into account actual consumption of auxiliary fuel oil in process boilers.

Annexure 5.1

Working for Norms of Consumption of Power and Heat Energy for Production of Acrylic Fibers

Table 5.1.1 : Power Purchase, Generation & Consumption in the Past and at Present

(Figures in Thousand Units)

	Power Purchased	Power Generated in UPS	Power Generated in DG	Power Generated (Total)	Total Power Consumption	Prod. of Fibers (Tones)
Year 2000-01	31097			4619	35716	2568
Year 99-2000	38924			5094	44018	3270
On 27/5/2002	109.666	0.42	10.44	10.86	120.526	93.218
May 2002 (Till 27/5/02)	2967	3	316	319	3286	2618
On 22/4/02	96	1.865	20.4	22.265	118.265	85.[illegible]81
April 2002 (Till 22/4/02)	2338	3	242	245	2583	2051.94
April 2000	3081	61	621	682	3763	2902
May 2000	3098	26	969	995	4093	2869
June 2000	3565	2	453	455	4021	2798
July 2000	3559	2	560	563	4122	2974
August 2000	3742	6	380	387	4129	2864
September 2000	3417	1	462	463	3880	2629
October 2000	3508	1	443	444	3952	2731
November 2000	3462	0	320	320	3782	2708
December 2000	823	0	108	108	931	558
January 2001	260	0	53	53	313	0
February 2001	620	0	59	59	679	259
March 2001	2021	3	191	194	2215	1087
April 2001	2834	6	267	273	3107	1812
May 2001	3654	20	442	462	4116	2911
June 2001	2994	6	308	313	3307	2064
July 2001	3829	5	377	382	4211	3040
August 2001	3936	2	388	390	4326	3003
September 2001	3653	3	431	435	4088	2711
October 2001	3629	4	346	351	3980	2910
November 2001	3266	0	320	320	3586	2844
December 2001	783	0	98	98	881	608
January 2002	2105	1	264	266	2371	1627
February 2002	2820	1	180	181	3001	2451
March 2002	3228	1	320	321	3549	2805

Table 5.1.2: Production of Fibers & Consumption of Fuels

(Figures in Thousand Liters or Tones)

	Furnace Oil	HPS	LDO (For Boiler)	HSD / LDO (EFS)	Total Fuel Oil	Rice Husk	Prod. of Fiber
Year 2000-01	16384				16384		25683
Year 99-2000	20664				20664		32709
On 27/5/2002	0	0	0	0	0	146.91	93.2184
May 2002 (Till 27/5/02)	0	0	7	8	14.593	4076	2618
On 22/4/02	0	0	0	0.07	0.07	133.98	85.881
April 2002 (Till 22/4/02)	0	17	11	4	32.221	3324	2051.94
April 2000		1434	13	50	1497.66	0	2902
May 2000		1475	4	50	1529.36	0	2869
June 2000		1467	6	47	1519.41	0	2798
July 2000		1309	106	49	1463.58	0	2974
August 2000		1481	35	49	1564.09	0	2864
September 2000		1438	2	49	1488.30	0	2629
October 2000		1479	7	49	1535.19	0	2731
November 2000		1496	1	48	1545.52	0	2708
December 2000		338	3	13	354.516	0	558
January 2001		34	13	1	47.72	0	0
February 2001		206	3	7	216.573	0	259
March 2001		728	10	27	765.39	0	1087
April 2001		920	0	36	955.143	0	1812
May 2001		749	0	51	800.344	971	2911
June 2001		429	2	41	472.943	1664	2064
July 2001		597	1	52	650.307	2174	3040
August 2001		647	3	53	702.647	2190	3003
September 2001		205	10	32	245.706	3307	2711
October 2001		97	0	11	108.11	4468	2910
November 2001		191	0	9	199.856	4341	2844
December 2001		18	0	1	19.138	941	608
January 2002		45	3	1	49.607	3022	1627
February 2002		102	23	3	128.538	3882	2451
March 2002		31	17	3	51.329	4502	2805

Table 5.1.3 : Past Observed Consumption Norms of Power and Fuels Per Ton of Fiber Production

(Consumption Per MT of Fiber)

Time Period	Production Capacity (MT)	Fiber Production (MT)	Capacity Utilization (%)	Power Consumption (kWh)	Husk Cons. (MT)	Fuel Oil for Steam (Liters)
Year 2000-01	36000	25683	71%	1391	0.0	638
Year 99-2000	36000	32709	91%	1346	0.0	632
On 27/5/2002	98.63	93	95%	1293	1.6	0
May 02 Till 27/5/02	2663	2618	98%	1255	1.6	6
On 22/4/02	98.63	86	87%	1377	1.6	1
April 02 Till 22/4/02	2170	2052	95%	1259	1.6	16
April 2000	3000	2902	97%	1297	0.0	516
May 2000	3000	2869	96%	1427	0.0	533
June 2000	3000	2798	93%	1437	0.0	543
July 2000	3000	2974	99%	1386	0.0	492

August 2000	3000	2864	95%	1441	0.0	546
September 2000	3000	2629	88%	1476	0.0	566
October 2000	3000	2731	91%	1447	0.0	562
November 2000	3000	2708	90%	1396	0.0	571
December 2000	3000	558	19%	1667	0.0	635
January 2001	3000	0	0%			
February 2001	3000	259	9%	2619	0.0	836
March 2001	3000	1087	36%	2037	0.0	704
April 2001	3000	1812	60%	1714	0.0	527
May 2001	3000	2911	97%	1414	0.3	275
June 2001	3000	2064	69%	1602	0.8	229
July 2001	3000	3040	101%	1386	0.7	214
August 2001	3000	3003	100%	1441	0.7	234
September 2001	3000	2711	90%	1508	1.2	91
October 2001	3000	2910	97%	1368	1.5	37
November 2001	3000	2844	95%	1261	1.5	70
December 2001	3000	608	20%	1448	1.5	31
January 2002	3000	1627	54%	1457	1.9	30
February 2002	3000	2451	82%	1225	1.6	52
March 2002	3000	2805	93%	1265	1.6	18

Notes:

1. March 2001. Commissioning of extra effect in solvent recovery
2. October 2001: Commissioning of vapor absorption chillers
3. Commissioning of first boiler converted to husk firing from oil firing 27-May-01
4. Commissioning of second boiler converted to husk firing from oil firing 27-Aug-01
5. Commissioning of third boiler converted to husk firing from oil firing 31-Mar-02
6. In Subsequent Tables Consumption of Oil and Husk has been converted to Thermal units. This has been done, considering boiler efficiency of 80 % and calorific value of 3500 K Cal/ Kg, in case of husk fired boilers, boiler efficiency of 85% and calorific value of 9600 K Cal/liter in case of oil fired boilers.

Table 5.1.4: Present Norms of Consumption of Power and Heat Energy

(Consumption Per MT of Fiber)

	Production Capacity (MT)	Fiber Production (MT)	Capacity Utilization (%)	Power Cons. (kWh)	Husk Cons. (MT)	Fuel Oil for Steam (Liters)	Total Heat Ths. K Cal
April 02 Till 22/4/02	2170	2052	95%	1258.79	1.6198	15.7	4664
On 22/4/02	98.63	85.88	87%	1377.08	1.5601	0.8	4375
On 27/5/2002	98.63	93.22	94%	1292 94	1.576	0	4413
May 02 Till 27/5/02	2663	2618	98%	1255.25	1.557	5.6	4405

Notes:

1. Data set marked XX, not considered due to low capacity utilization
2. Average. 1296 kWh and 4464 Thousand K Cal. Per MT of Fiber
3. High: 1377 kWh (106% of average) and 4664 K Cal. (104% of average) Per MT of Fiber
4. Low: 1255 kWh (91% of average) and 4375 K cal (94% of average) Per MT of Fiber

Table 5.1.5. Norms of Consumption before Commissioning of Extra Effect in Solvent Recovery & Vapor Absorption Chillers

(Consumption Per MT of Fiber)

	Production Capacity (MT)	Fiber Production (MT)	Capacity Utilization (%)	Power Cons. (kWh)	Husk Cons. (MT)	Fuel Oil For Steam (Liters)	Total Heat Ths. K Cal	
January 2001	3000	0	0%	0	0.00	0	0	XX
February 2001	3000	259	9%	2619	0.00	836	6821	XX
December 2000	3000	558	19%	1667	0.00	635	5180	XX
March 2001	3000	1087	36%	2037	0.00	704	5744	XX
September 2000	3000	2629	88%	1476	0.00	566	4620	
November 2000	3000	2708	90%	1396	0.00	571	4657	
October 2000	3000	2731	91%	1447	0.00	562	4587	
June 2000	3000	2798	93%	1437	0.00	543	4431	
August 2000	3000	2864	95%	1441	0.00	546	4456	
May 2000	3000	2869	96%	1427	0.00	533	4350	
April 2000	3000	2902	97%	1297	0.00	516	4211	
July 2000	3000	2974	99%	1386	0.00	533	4350	

Notes:

1. Data set marked XX, not considered due to low capacity utilization
2. Average 1413 kWh and 4458 Thousand K Cal. Per MT of Fiber
3. High. 1476 kWh (104% of average) and 4657 K Cal. (104% of average) Per MT of Fiber
4. Low: 1297 kWh (88% of average) and 4211 K Cal (90% of average) Per MT of Fiber

Table 5.1.6: After Commissioning of Extra Effect in Solvent Recovery but Before Vapor Absorption Chiller

(Consumption Per MT of Fiber)

	Production Capacity (MT)	Fiber Production (MT)	Capacity Utilization (%)	Power Cons. (kWh)	Husk Cons. (MT)	Fuel Oil for Steam (Liters)	Total Heat Ths. K Cal	
April 2001	3000	1812	60%	1714	0.00	527	4300	XX
June 2001	3000	2064	69%	1602	0.81	229	4128	XX
September 2001	3000	2711	90%	1508	1.22	91	4155	
May 2001	3000	2911	97%	1414	0.33	275	3177	
August 2001	3000	3003	100%	1441	0.73	234	3952	
July 2001	3000	3040	101%	1386	0.72	214	3748	

Notes:

1. Data set marked XX, not considered due to low capacity utilization

2. Average: 1437 kWh and 3758 Thousand K Cal. Per MT of Fiber
3. High: 1508 kWh (105% of average) and 4155 K Cal. (111% of average) Per MT of Fiber
4. Low: 1386 kWh (92% of average) and 3177 K cal (76% of average) Per MT of Fiber

Table 5.1.7: After Commissioning of Extra Effect in Solvent Recovery and Vapor Absorption Chillers

(Consumption Per MT of Fiber)

	Production Capacity (MT)	Fiber Production (MT)	Capacity Utilization (%)	Power Cons. (kWh)	Husk Cons. (MT)	Fuel Oil for Steam (Liters)	Total Heat Ths. K Cal
December 2001	3000	608	20%	1448	1.55	31	4589
January 2002	3000	1627	54%	1457	1.86	30	5449
February 2002	3000	2451	82%	1225	1.58	52	4864
March 2002	3000	2805	93%	1265	1.61	18	4644
November 2001	3000	2844	95%	1261	1.53	70	4847
October 2001	3000	2910	97%	1368	1.54	37	4602

Notes:

1. Data set marked XX, not considered due to low capacity utilization
2. Average: 1280 kWh and 4739 Thousand K Cal. Per MT of Fiber
3. High: 1368 kWh (107% of average) and 4864 K Cal. (103% of average) Per MT of Fiber
4. Low: 1225 kWh (90% of average) and 4602 K cal (95% of average) Per MT of Fiber